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PRELIMINARY REPORT OF THE YALE PERUVIAN EXPEDITION

BY

PROFESSOR HIRAM BINGHAM, DIRECTOR

The Peruvian Expedition, as approved by the Yale Corporation, consisted of seven men: Professor Hiram Bingham, Director, Professor Isaiah Bowman, Geologist-Geographer, Professor H. W. Foote, Collector-Naturalist, Dr. Wm. G. Erving, Surgeon, Mr. Kai Hendriksen, Topographer, Mr. H. L. Tucker, Archæological Engineer, and Mr. P. B. Lanius, Assistant.

We landed at Mollendo, the chief seaport of southern Peru, in June, 1911, and went at once to Cuzco, the old Inca capital. The first field of operations was the Urubamba River and its affluents, including the hitherto unknown Rio Pampaconas. The second was a cross-section from the head of canoe navigation on the Urubamba south over the Andes to the Pacific Ocean. The third was the neighborhood of Mount Coropuna and Lake Parinacochas. For this last, Arequipa was used as a base. The field work occupied five months. The expedition was divided into three parties to do archæological, geological and topographical exploration.

The Peruvian Government, acting on the initiative of President Leguia, gave the expedition free entry for all their supplies and loaned the services of several soldiers and non-commissioned officers. Through the courtesy of President Taft, the United States Coast and Geodetic Survey and the Geological Survey loaned the necessary topographical instruments, and the Army a complete medical equipment, including typhoid vaccine.

The topographical work was in charge of Mr. Kai Hendriksen, formerly of the University of Copenhagen, and later of the United Coast and Geodetic Survey on the Canadian boundary.

Mr. Hendriksen reports that he made seventeen topographic maps, took fifteen observations for latitude and twenty-seven observations for longitude and made several plans of ruins. The following maps are the results of his surveys:

"One detailed topographic map covering 50 square miles (scale 1:45,000; relief in contours, interval 100 feet), showing characteristic physiography of Central Andes, west of Cuzco. Astronomical basis: One observation for latitude, two observations for azimuth and longitude.

One detailed topographic map covering region 1½ miles long, ½ mile wide (scale 1 in.=300 feet [1:3,600]; contour interval, 20 feet, in places, 5 feet), of *quebrada* near Cuzco, where interesting bones and ash-deposits were found. The map shows bench marks to which photographs and discoveries were tied.

One detailed topographic map covering region 2 miles long, 1 mile wide (scale 1:9,000; contour interval, 20 feet), of Cuzco and vicinity. Shows the above-mentioned *quebrada* and the famous ruins near Cuzco.

One topographic map (standard*) (covering region about 30 miles long, 5 to 10 miles wide) of the Urubamba valley from Piscocucho to Mandor Pampa. The map shows the position of most of the ruins found in the Urubamba valley. Jungle in the greater part of the valley. Astronomical basis: One observation for latitude, two observations for azimuth and longitude.

One topographic map (standard) (covering region about 30 miles long, about 5 miles wide) of the Vilcabamba valley from Chaullai to Vilcabamba. Jungle in the lower part of the valley. Astronomical basis: One observation for latitude, two observations for azimuth and longitude.

One route-survey, with astronomical positions, about 60 miles long, showing form-lines of about 200 feet difference in elevation. The survey and return was made in ten days on foot from Vilcabamba to Esperitu Bampa, where Inca ruins were found. The trail followed was very narrow through heavy jungle. Much rain. No accurate survey could be made. Directions by prismatic compass, distance by time and pedometer, elevation by aneroid. Astronomical control: Five observations for latitude, eleven observations for azimuth and longitude.

Quick route-survey from Vilcabamba to Abancay (by Prof. I. Bowman). Astronomical basis: Two observations for latitude.

Ten topographic maps (standard), covering region 250 miles long, 5 to 20 miles wide, 40 working days. Cross-section over the Andes from Abencay to the Pacific Coast (Camana). (The map of Coropuna is a part of this map.) Astronomical control: Fifty observations for latitude, ten observations for azimuth and longitude.

One detailed topographic map (scale 1:45,000; contour interval, 100 feet), covering thirty square miles of pass between Lambrama and Chuquibambilla. Shows characteristic glacial topography.

Three large-scale plans of the ruins of Aquente and Torontoy. Measured by tape and stadia, with accurate measurements of each building.

Several accurate measurements of smaller ruins.

All the standard topographic maps are done by exact methods of survey: distances by micrometer screw combined with triangulation, elevations by vertical angle. The distances are determined with an accuracy of 50 to 100 feet, elevations with an accuracy of about 30 feet. The more detailed topographic maps were made by the same method. The two detailed topographic maps on a very large scale, near Cuzco, were made by stadia and vertical angles.

A bathymetric and topographic survey was made of Lake Parinacochas, 11,500 feet above the sea. A folding boat was successfully carried from this country. According to the story given us by the natives, Parinacochas was navigated for the first time. We found its length to be about 17 miles and its width 6 miles. The greatest depth is not over six feet. At the time of our visit in the dry season it had somewhat shrunk so that we failed to find any depth over four feet six inches. A sample of the water was brought home to be analyzed. On the shores of the lake were found many primitive ruins indicating the former presence of a large population.

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* The standard maps of the expedition are: scale 1:90,000; contour interval 200 feet.

Mount Coropuna was successfully climbed by the Director and Mr. H. L. Tucker, and later was triangulated by Mr. Hendriksen. A comparison between the mercurial barometer taken to the top and one read simultaneously in Arequipa, 100 miles away, gave an altitude of 21,640 feet. Mr. Hendriksen's careful survey and triangulation of the mountain from its vicinity to the sea coast raised this estimate to 21,703, with a mean error of 35 feet. The altitude given to Coropuna on the map of Peru by the Royal Geographical Society, 22,799 feet, is thus seen to be more than 1,000 feet too high, and Coropuna, instead of being the highest mountain in America, probably only occupies fourth or fifth place.

The geological and geographical work was in charge of Professor Isaiah Bowman, who makes the following report of his results:

"(1) Geological map across the Andine Cordillera from the mouth of the Timpia southward along the 73d meridian to Camaná on the coast.

(2) Physiographic interpretation of the belt of country traversed.

(3) Meteorological observations along the line of traverse, including notes on wind, clouds, temperature, humidity, etc., and a set of about fifteen daily temperature curves for typical stations.

(4) Notes on the anthropogeography of the natural regions which were crossed, including the relation of the people to the physiography and geology; also trade routes and movements, products, systems of land tenure, rotation of crops on artificial terraces, the rubber industry, and other data of economic geography.

(5) In further explanation of (1) and (2):

(a) Collection of fossils (Devonian, Carboniferous, Cretaceous, and Tertiary, chiefly) from six type localities.

(b) Interpretation of the structure section across the cordillera.

(c) Interpretation of the geology of the Cuzco basin, including the finding of Tertiary fossils and the origin of the famous "Rodadero" wrongly supposed for many years to have been glaciated.

(d) Determination of the level of perpetual snow, and the limits of past glaciation—of special importance in connection with the problem of decreasing level of snow-line towards the equator.

(e) Glacial forms and their interpretation: a study of the effects of glacial erosion in valleys from which the ice of glacial times has been withdrawn. The results of these studies bear out in a striking way the conclusion that ice is a powerful agent of denudation. Special attention was given to the glacial alluvium about Cuzco in order to determine the importance of human remains found therein.

(f) Clear geologic and physiographic evidence of past climatic changes beyond the limits of glaciation, especially in the deep valleys of the Cordillera and in the desert of the coast region.

(g) Evidence that the great coastal terraces have had a complex history, including a submergence in the Tertiary and a later stripping still in progress.

(h) Discovery that the great Tertiary cycle of erosion ending in the formation of well-graded mature slopes affected this region as well as the region farther south studied in the Yale South American Expedition of 1907.

(i) A study of the relation of the forests of the region to water supply slope exposure, and soils.

(j) A set of observations on the temperature of water and air along the Peruvian coast in relation to (1) the counter current sometimes visible, and (2) to the more abundant showers on the coast hills, a feature especially important during the past season.

(k) Topographic sketch map of the Urubamba valley between Rosalina and Pongo de Mainique, indicating the form of the land by contours and showing the positions of a large number of rapids and whirlpools.

(l) Route map across the Cordillera Vilcabamba indicating geologic boundaries and position and relation of the principal glacial forms.

(m) Pleistocene history of the Lake Titicaca basin.

The natural history collections were in charge of Professor H. W. Foote, who makes the following report:

"On the advice of our biological department, collecting was limited mainly to insects and non-flowering plants, including mosses and liver-worts. This was done partly because it was impossible for one man to collect effectively in many different lines and partly because the birds, animals, and flowering plants of Peru are fairly well known, while the orders which were collected were not.

Collecting was chiefly carried on along the valleys of the Urubamba, Vilcabamba, and Pampaconas Rivers, a distance of perhaps 250 miles, from an altitude of over 12,000 feet (at Vilcabamba) to 3,000 feet (Santa Ana). A fair collection was also made about Cuzco. It was the dry season and winter, when insects are not so plentiful as in the wet season when it is warmer. Nevertheless, approximately 3,000 specimens of plants and insects were obtained, besides several hundred land shells.

Little or no collecting has been done before in the districts visited and it is believed that the collection will add materially to our knowledge of geographical distribution. It is also probable that some new species have been obtained. Arrangements have been nearly completed to have the collections investigated by specialists who will publish their reports later. Ultimately, it is hoped to deposit most of the collecton in Peabody Museum."

A few archæological discoveries were made by the Director. Among them are the ruins of a number of Inca or pre-Inca cities, including: (1) Macchu Pichu, a city probably built by the "megalithic race" who preceded the Incas. The ruins are on an almost inaccessible ridge, 2,000 feet above the Urubamba River. They are of great beauty and magnificence and include palaces, baths, temples and about 150 houses. Carefully cut blocks of white granite, some of them twelve feet long, were used in the construction of the walls. The city was surveyed by Messrs. Tucker and Lanius.

(2) The temple of Yuracrumiu, the centre of the Inca religious cult after the fall of Cuzco, containing a carved monolith 185 feet in circumference.

(3) Vitcos, the palace and capital of Manco Capac, the last Inca, probably built after his retreat from before Pizarro's conquering army.

(4) Vilcapampa, a purely Inca town, now completely buried in the dense jungle of the Rio Pampaconas, but containing characteristic Inca pottery, and bronze implements.

(5) A number of other primitive towns in the coastal desert provinces, two of which were marked by volcanic boulders covered with pictographs including drawings of jaguars, llamas, and dancing men.

Near Cuzco a wall was discovered, probably over 100 feet long, partially exposed by recent erosion. Excavation revealed the fact that it was buried beneath six feet of gravel deposited on both sides and on top of it by the action of water. The wall was about four feet in thickness, faced with carefully cut polygonal stones on both sides, the middle being filled in with rubble. As the wall resembles some of the oldest and best-known walls in Cuzco and here was found to be covered by compact gravels, the age of this type of wall will depend largely on the geological evidence regarding the gravel. If this gravel should prove to have been deposited in glacial times it would revise the prevailing notions. The natives generally consider it to be Inca; some scholars regard it as pre-Inca. The geological evidence appears to be decidedly in favor of the latter view.

Human bones were found in the same valley, embedded under seventy-five feet of gravel, interstratified with the gravel beds and with the bones of several lower animals. They were excavated by the Director and Professor Bowman in the presence of Professor Foote, who photographed the bones in position.

Professor Bowman made a detailed study of the geology of the surrounding region and makes the following preliminary report:

"The geographic and geologic study of the bones found near Cuzco indicated that they were contemporaneous with the compact gravels in which they were embedded. They were disposed in the form of a lens about 10 feet long and 6 inches thick. From (1) their disposition with respect to each other (they were jumbled and essentially flat), (2) their relations with the bedding planes (some of which passed directly through the bone deposit), and (3) their worn condition (the finer details are absent), it is concluded that they were interstratified with the gravel beds. The age of the beds thus becomes the determining fact in the interpretation.

"From a detailed study of the geology of the upper Cuzco basin with special reference to glacial forms, it is concluded (1) that the beds belong to the Pleistocene series, (2) that the bones were deposited during a period of pronounced alluviation, and (3) that since the deposition of the bones at least 75 feet of gravel were deposited over them and later partly eroded, an erosion that is still in progress and to whose activity we owe the exposure.

"It should be remembered that while compelled to refer the gravel beds of this locality to the Pleistocene series I have yet to determine their place in that series. When this is done the antiquity of the vertebrate remains may be more safely approximated than now. A provisional estimate would hardly be less than 10,000 years; it could not exceed the maximum glaciation of the last glacial period generally estimated at 75,000 years."

The bones were soaked in melted vaseline, packed in cotton-batting and brought safely to New Haven, where they have been examined by Dr. George F. Eaton, curator of osteology in the Peabody Museum of Yale University. He finds that the fragments represent sixteen distinct bones, including a fragment of a human skull, two imperfect ribs, fragments of a pelvis and femura of at least three individuals. As there are fragments of only eight human bones, it is impossible to say much about the individuals whom they represent. Of the physical characteristics of the one represented by a femur and an associated pelvis Dr. Eaton reports that the following logical inferences may be drawn: "We may reasonably suppose him to have been a remarkably thickset and powerful man about 5 feet and 4 inches (1.625 m.) in height. As his skeletal characters are not sufficiently primitive to differentiate him specifically from *Homo sapiens*, he should be provisionally referred to that species.

Such a course will also comply with your request that the identification of this material should be made without regard to any purely geological indications of age."

Among the eight other fragmentary bones, is a much battered shaft of the left tibia "from the skeleton of a wolf or wolf-like dog." There is also the "cannon bone" of the left hind leg of a bovine animal, together with a fragment of the right radius and a fragment of the first right thoracic rib. While the exact specific identification of the three last named specimens must rest largely on the determination of their geological age, there is no doubt, says Dr. Eaton, that they are either from the Bison, *Bos americanus,* or from one of the closely related species. The remainder of the collection comprises four more or less fragmentary bones that "are confidently referred to *Lama guanacus,* the Guevaco, the feral species from which the domestic breeds of the Llama and Alpaca are supposed to be derived." If these bones do represent the bison, it is, I believe, the first instance from South America.

Although the bones belong, possibly without exception, to the present day fauna of the new world, the geological evidence points to the possibility of the remains being of glacial or inter-glacial time. Further examination of the region where these bones were found is needed before we shall be able to speak more definitely about their age. There have been several reports from placer gold mines in the central Andes of arrow heads and bones having been washed out of what the mining engineers supposed was glacial gravel. But direct evidence for glacial man in South America is so unreliable that reputed discoveries should not be accepted without the utmost caution.

The bones brought home by the expedition will be presented to the Peabody Museum of Yale University, together with photographs taken by Professor Foote. It seems to me quite possible that the bones and the before-mentioned wall will be found to belong to the same geological period, whatever that may be.

In conclusion, it should be remembered that our work was largely reconnaissance exploration. We hope to send out other expeditions to make thorough examination of the more important discoveries.